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Chopping down the syntax tree

What constructions can do instead

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Word order, argument structure and unbounded dependencies are among the most important topics in linguistics because they touch upon the core of the syntax-semantics interface. One question is whether "marked" word order patterns, such as *The man I talked to* vs. *I talked to the man,* require special treatment by the grammar or not. Mainstream linguistics answers this question affirmatively: in the marked order, some mechanism is necessary for "extracting" *the man* from its original argument position, and a special placement rule (e.g. topicalization) is needed for putting the constituent in clause-preceding position. This paper takes an opposing view and argues that such formal complexity is only required for analyses that are based on syntactic trees. A tree is a rigid data structure that only allows information to be shared between local nodes, hence it is inadequate for non-local dependencies and can only allow restricted word order variations. A *construction,* on the other hand, offers a more powerful representation device that allows word order variations – even unbounded dependencies – to be analyzed as the side-effect of how language users combine the same rules in different ways in order to satisfy their communicative needs. This claim is substantiated through a computational implementation of English argument structure constructions in Fluid Construction Grammar that can handle both comprehension and formulation.

1. Introduction

At the core of every linguistic approach is how the theory handles argument structure and its relation to word order. Mainstream linguistics assumes that languages have a basic word order and therefore treat variations on this order as deviant. This is apparent in a lot of the terminology commonly used by linguists, such as "topicalization", "WH-fronting", "scrambling", "extraposition", and so on. A lot of these analytical tools have been invoked to deal with so-called "unbounded" (or long-distance) dependencies, as in the relative clause *the person I met yesterday.*

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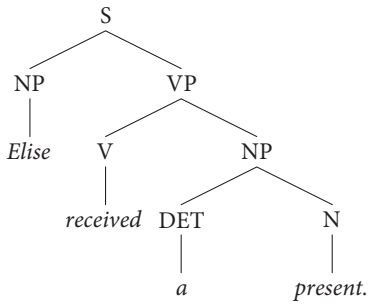
Here, it is common practice to say that the *the person* has been "extracted" from its original argument position and is now placed in clause-preceding position.

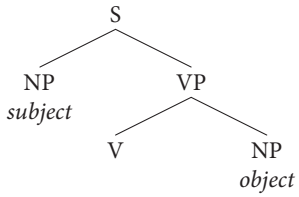
But what makes such unbounded dependencies so difficult? Many linguists assume syntactic trees (or rather: a phrase structure grammar) in their analysis. A tree is a hierarchical data structure consisting of a number of *nodes* that can only have one parent node, which means that information can only be shared locally between parent nodes and their children (sometimes also called *mother* and *daughters).* Example (1) shows a simple tree structure.

(1)



When syntactic trees are used as the central or only representation device, all other kinds of information must be "read off" the tree. For example, grammatical functions such as subject and object need to be defined in terms of their position in the tree representation, as illustrated in example (2). As noted by Kaplan and Zaenen (1995, 137), such analyses implicitly claim that "the primitives of a tree representation, namely, linear order, dominance (but not multi-dominance) relations and syntactic category labels, are adequate to represent several types of information that seem quite dissimilar in nature. They have been used, for example, to represent the dependencies between predicates and arguments needed for semantic interpretation […]."

(2)



The problem of unbounded dependencies occurs when *non-local* information needs to be shared. That is, information between nodes that have no immediate-dominance relation between them. As already shown by Chomsky (1956), a basic phrase structure grammar does not have the necessary expressive power for solving this problem. If you however insist on using syntactic trees for analyzing

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sentences, you need to incorporate other mechanisms such as transformations (Chomsky 1977) or filler-gap rules (Gazdar 1981).

The formal complexity required for handling unbounded dependencies stands in stark contrast to the intuitively appealing explanations that are offered in cognitive-functional linguistics. In this tradition, unbounded dependencies are explained as a side-effect of functional considerations. For instance, the "marked" word order in the example *the person I talked to yesterday* indicates a difference in information structure: the speaker asserts something "about" *the person,* so this constituent takes clause-preceding position. The hierarchical constituent structure of the example, however, remains the same as in the unmarked clause *I talked to the person yesterday.* Functional linguists therefore typically propose different *layers* that try to separate different sources of information from each other (such as functional structure, information structure and illocutionary force). However, separate layers create an "interface" problem to keep these layers in sync with each other, and so far no one has been able to achieve an adequate formalization of the cognitive-functional approach.

In this article, I will show that it is nevertheless possible to combine the formal rigor of phrase structure analyses to the theoretical elegance of cognitive-functional analyses by adopting a more powerful data structure: *constructions* (Fillmore 1988). Constructions have the expressive power to both access and store all linguistic information in a single representation, which allows us to "cut down the syntax tree" and treat different sources of linguistic information on equal footing with syntactic structure. I substantiate my claims through a computational implementation of English argument structure constructions in Fluid Construction Grammar (FCG; www.fcg-net.org; Steels 2011)[1] that works for both formulation and comprehension.

2. Argument structure in tree representations

In order to better understand the limitations of syntactic trees, it is best to start with a standard phrase structure grammar (also called a context-free grammar). A phrase structure grammar consists of a set of rewrite rules. Example (3) shows a toy grammar that is capable of generating four English transitive clauses (e.g. *the man saw the woman*). Each rule consists of a non-terminal symbol on the left-hand side, and a string of terminal and/or non-terminal symbols on the right-hand side.

1. For a comprehensive introduction to FCG and its formal notation, see Steels (to appear).

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(3) a. S → NP VP
b. NP → DET N
c. VP → V NP
d. DET → *the*
e. N → *man*
f. N → *woman*
g. V → *saw*

Suppose that the toy grammar needs to be extended in order to handle topicalization, as in *the woman the man saw.* This is not a trivial problem. First of all, we need to add a new rule that allows this pattern to be generated:

(4) S → NP S

However, this new rule now causes the grammar to generate unacceptable sentences such as *the woman the man saw the woman,* while still rejecting valid topicalization clauses. We can solve the latter problem by adding another rule:

(5) VP → V

The grammar now accepts correct topicalization clauses such as *the man the woman saw,* but it still overgenerates unacceptable sentences. In order to avoid this problem, it is necessary to increase the expressive power of the formalism. In the following two subsections, I will discuss two of several possible solutions. An important disclaimer is that these sections offer only a basic introduction to both solutions aimed at readers who are less familiar with formal approaches to grammar. The fine-grained details can be found in the references in both subsections.

2.1 Feature structures and unification

One solution that has proven its worth in formal grammars is to no longer treat the symbols of a phrase structure grammar as atomic units, but as complex categories that you can describe with feature-value pairs (Kay 1979). Example (6) shows how the non-terminal symbol V can be described using the features CAT (category) and VAL (valence). The value of the feature VAL is a set of constituents that the verb needs to combine with locally in order to form a valid sentence.

(6) $\begin{bmatrix} \text{CAT} & \textit{verb} \\ \text{VAL} & \langle \text{NP}_1, \text{NP}_2 \rangle \end{bmatrix} \rightarrow \textit{saw}$

Feature structures make it possible to handle unbounded dependencies without movement, as shown by Gazdar (1981), whose solution has been adopted in a.o. Head-Driven Phrase Structure Grammar (HPSG; Pollard and Sag 1994) and

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Sign-Based Construction Grammar (SBCG; Sag 2010). The solution consists of three steps. First of all, the grammar needs a way to identify a "gap" (or a missing element) in a sentence. This can be formalized using a feature called GAP (also called SLASH in the HPSG literature), whose value is empty for all "basic" lexical entries. The rule for *saw* now looks as follows:

(7) $\begin{bmatrix} \text{CAT} & \textit{verb} \\ \text{VAL} & \langle \text{NP}_1, \text{NP}_2 \rangle \\ \text{GAP} & \langle\rangle \end{bmatrix} \rightarrow \textit{saw}$

When the object has been topicalized, there is a problem for this rewrite rule because the object (NP_2) cannot be found in its default argument position in the "domain" of the verb (as illustrated before in example 2). The grammar therefore needs to be expanded with a lexical rule or some other principle that can transform the valence of the verb by taking the object out and putting it into the value of the GAP feature. Such a lexical rule derives the following lexical item:

(8) $\begin{bmatrix} \text{CAT} & \textit{verb} \\ \text{VAL} & \langle \text{NP}_1 \rangle \\ \text{GAP} & \langle \text{NP}_2 \rangle \end{bmatrix} \rightarrow \textit{saw}$

Summarizing, the first step consists of identifying a missing element in the sentence, and then to store information about that element in the feature GAP. The next step is to "percolate" information about the features VAL and GAP upwards in the tree in a stepwise fashion so they can be used for constraining the grammar. For instance, we can now constrain the rewrite rule *VP → V NP* by only allowing verbs with an empty GAP feature to appear on the right-hand side of the rule, as illustrated in example (9).[2]

(9) $\begin{bmatrix} \text{CAT} & \textit{VP} \\ \text{VAL} & \langle \text{NP}_1 \rangle \\ \text{GAP} & \langle\rangle \end{bmatrix} \rightarrow \begin{bmatrix} \text{CAT} & \textit{V} \\ \text{VAL} & \langle \text{NP}_1, \text{NP}_2 \rangle \\ \text{GAP} & \langle\rangle \end{bmatrix} \quad [\text{CAT } \textit{NP}]$

2. Note that the VAL feature of the verb on the right-hand side contains two constituents, while the VP on the left-hand side contains only one element. The reason is that the example follows a simplified version of the Argument Realization Principle that is assumed in theories such as HPSG and SBCG: when the verb is combined with NP_2, this argument is "consumed" from the valence list, meaning that the VP now only has to combine with NP_1, which in turn consumes this constituent from the VP's valence. Valid sentences are formed when the VAL feature becomes empty (or fully "saturated"). For more details on the Argument Realization Principle, see Sag et al. (2003).

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However, when we have to deal with a "gap", this information needs to be communicated upwards in the tree representation until the "filler" of that gap has been found. Example (10) achieves this for the rewrite rule *VP → V*, repeating a variable 1 in the GAP features of both VP and V to indicate that their values must be the same.

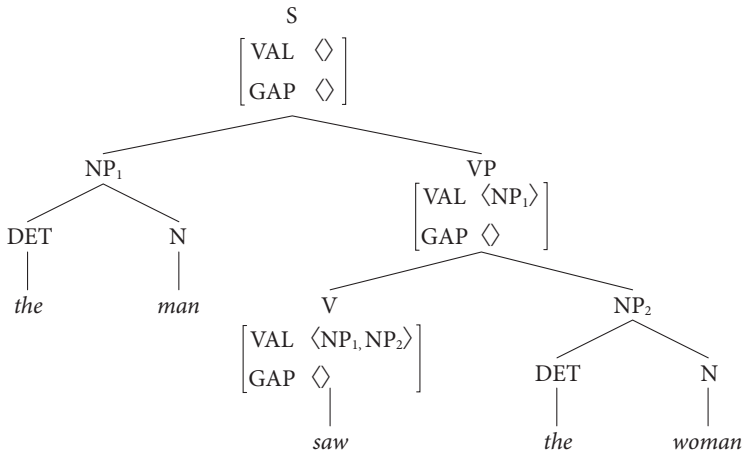
(10) $\begin{bmatrix} \text{CAT} & VP \\ \text{VAL} & \langle \text{NP}_1 \rangle \\ \text{GAP} & \boxed{1} \end{bmatrix} \rightarrow \begin{bmatrix} \text{CAT} & V \\ \text{VAL} & \langle \text{NP}_1 \rangle \\ \text{GAP} & \boxed{1} \end{bmatrix}$

Both examples (9) and (10) require the VP to combine with NP_1 to form a valid S node, which happens through the rewrite rule *S → NP VP.* Example (11) shows what the rule looks like when it is expanded with feature-value pairs for describing each symbol. As before, the value of the GAP feature of the VP is percolated to the GAP feature of S by repeating the variable 1.

(11) $\begin{bmatrix} \text{CAT} & S \\ \text{VAL} & \langle\rangle \\ \text{GAP} & \boxed{1} \end{bmatrix} \rightarrow [\text{CAT } NP] \begin{bmatrix} \text{CAT} & VP \\ \text{VAL} & \langle \text{NP}_1 \rangle \\ \text{GAP} & \boxed{1} \end{bmatrix}$

Example (11) is compatible with both unmarked clauses and topicalization clauses. In the sentence *the man saw the woman,* the rule applies together with the rewrite rules of example (9) and the basic lexical entry of *saw* as in example (7). In this case, both the VAL and GAP features of S are empty, which means that an acceptable sentence can be formed. Example (12) illustrates the tree representation of this analysis.

(12)



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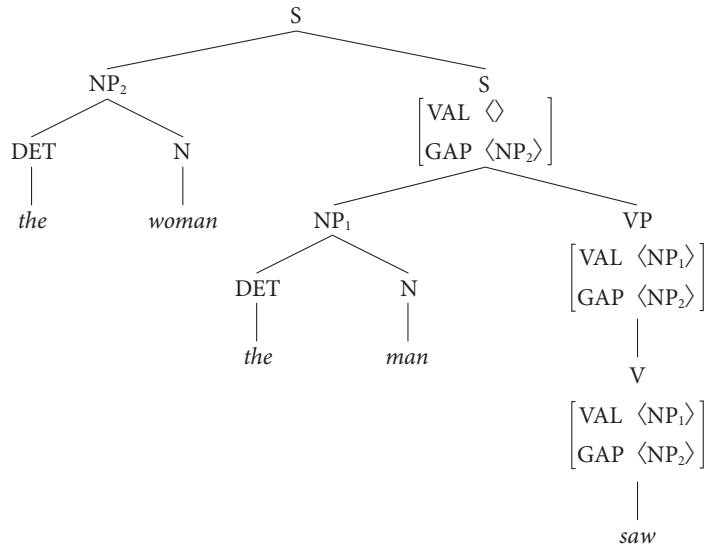
In the case of topicalization, as in *the woman the man saw,* the GAP feature has not been saturated yet. The rewrite rule in example (13), also called a filler-gap rule, takes care of this problem: the symbol S can now only be rewritten as *NP S* if the NP is also the filler of the GAP feature of S on the right-hand side of the rule. Now we have finally achieved the goal of our toy grammar: to accept both unmarked transitive clauses as well as topicalized transitive clauses, while avoiding the over-generation problem. Example (14) shows the tree representation of the sentence.

(13) $\begin{bmatrix} \text{CAT} & S \\ \text{VAL} & \langle\rangle \\ \text{GAP} & \langle\rangle \end{bmatrix} \rightarrow [\text{CAT } NP] \begin{bmatrix} \text{CAT} & S \\ \text{VAL} & \langle\rangle \\ \text{GAP} & \langle \text{NP} \rangle \end{bmatrix}$

(14)



(after lexical rule application)

2.2 Restructuring trees

Besides the filler-gap analysis, there exist plenty of other tree-based approaches that have more expressive power than basic phrase structure grammars. For example, whereas the symbols of a phrase structure grammar are single nodes or leafs in a syntactic tree, formalisms such as Tree-Adjoining Grammar (TAG; Joshi 1985) store elementary trees. For instance, a transitive verb form such as *saw* can be directly associated with a syntactic tree, as shown in example (15).

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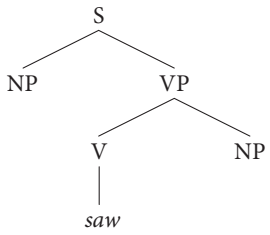
(15)

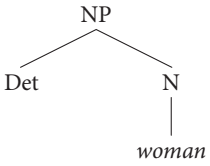


Examples (16a) and (16b) show elementary trees associated with the article *the* and the noun *woman*. A TAG grammar is able to combine both trees with each other through substitution: the subtree DET within example (16b) can be substituted by the tree of example (16a), thereby forming a fully instantiated noun phrase, as shown in example (16c). This NP can in turn substitute any of the NP nodes in example (15), yielding the same expressive power as a basic phrase structure grammar.

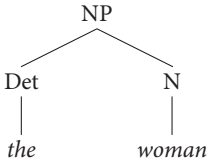
(16) a. Tree for *the*



b. Tree for *woman*



c. Tree for *the woman*



TAG goes beyond the expressive power of phrase structure through *adjunction*. That is, a subtree can be grafted onto any non-terminal node of another tree as long as it is compatible with it. First, a syntactic tree must be stored for every pattern that involves long-distance dependencies, as shown in example (17), which imposes the object position of the VP to remain empty.

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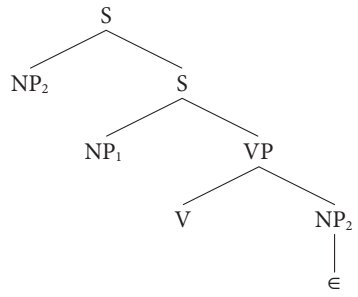
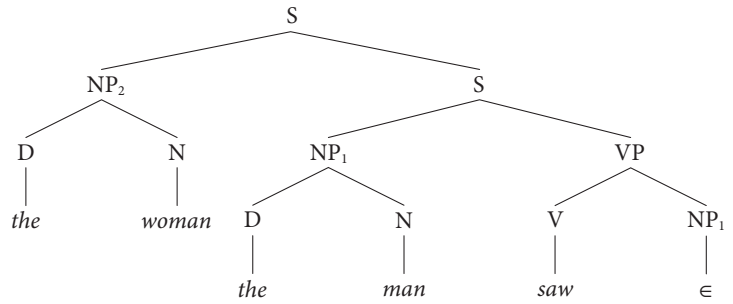
(17)



The subtree of example (15) is fully compatible with the VP-subtree of example (17), hence it can be grafted onto this part of the tree through adjunction. The NPs of the trees can then be substituted by instantiated NPs, resulting in the tree structure of example (18).

(18)



A TAG grammar does not require feature percolation because its elementary trees go beyond the locality of parent and children nodes, and instead allow nodes that are located higher in the tree to directly access for instance their grandchildren. One could thus argue that TAG is able to capture constructional effects in this way, and indeed advocates of related formalisms such as Data-Oriented Parsing (DOP) have explored tree substitution as a way to capture productivity in construction grammar (Bod 2009).

However, the main difference between a *construction* and a more complex tree representation is that a construction has unrestricted expressive power, which allows non-syntactic information to be treated independently of a syntax tree. Moreover, tree-based approaches with the expressive power of TAG or DOP still have to give special treatment to long-distance dependencies by analyzing them as deviations from some canonical order. Such formalisms are therefore not capable of adequately formalizing a functional analysis.

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3. Argument structure in constructions

In the past few decades, a more sophisticated approach to argument structure has emerged at the cross-section of cognitive-functional linguistics (Dik 1997; Verhagen 2005), frame semantics and construction grammar (Fillmore 1975, 1988; Goldberg 1995; Croft 1998), and pragmatics (Chafe 1994; Lambrecht 1994). Here, speakers and listeners are assumed to make a number of interrelated choices when they engage in linguistic communication, each of which has an impact on how a state-of-affairs is verbalized into a sentence. Within the boundaries of a single sentence, they must take the following considerations into account:

- Event-participant structure: The speaker wishes to communicate a particular state-of-affairs and needs to indicate the relation between an event and the participants that play a role in that event;
- Functional structure: The speaker chooses a vantage point from which to describe the state of affairs. For instance, active voice typically takes the viewpoint of the Agent of an event, whereas passive voice expresses the same event from a different perspective;
- Information structure: The speaker must present a sentence in such a way that the listener is able to relate its information to the discourse context.
- Illocutionary force and intersubjectivity: The speaker must somehow communicate the speech act of an utterance (such as assertion, request or command), and ground the deictic dimensions of the utterance with respect to the speech setting (e.g. spatiotemporal deixis such as present vs. past tense).

From a descriptive point of view, it makes sense to organize these different types of structures into separate layers, as is common practice in functional linguistics. However, this approach is extremely hard to formalize and to turn into an efficient usage model because language "resists the attempt of linguists to make it neat and clean" (Croft 2003, 50). That is, it is not always possible to cleanly decide in which layer a particular piece of information should be stored or in which order the language user should access that information. Moreover, separate layers introduce a synchronisation problem because all layers must interface with each other to keep their information consistent. Fortunately, construction grammar offers an alternative by proposing a *construction* as a uniform representation device for all linguistic knowledge. Charles J. Fillmore, widely recognized as the father of construction grammar, defined a construction as follows:

> By **grammatical construction** we mean *any* syntactic pattern which is assigned to one or more conventional functions in a language, together with *whatever* is linguistically conventionalized about its contribution to the meaning or the use of structures containing it. (Fillmore (1988), 36, italics added)

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I italicized the words *any* and *whatever* in this quote to emphasize the fact that constructions are able to represent any kind of mapping between meaning/function and form. For instance, as Fillmore (1988, 35) explains, constructions are not limited to the immediate-dominance constraints of phrase-structure rules (i.e. every phrase-structure rule is a relation between a parent and its immediate children in a local tree configuration) but can make direct reference to the linguistic information they require, wherever this information may be located.

In formal grammar terminology, one can thus say that constructions have *unrestricted* expressive power. This makes it easy for us to formulate generalizations that are difficult to express in a tree-based grammar. In the remainder of this paper, I will illustrate how only three generalizations can be formulated to capture argument order in the vast majority of English utterances. I do not claim that these three generalizations offer the most complete or best analysis of English word order and argument structure, but they illustrate what you can do with constructions that cannot be done in tree-based grammars. I will also offer a formal description of the constructions that operationalize these generalizations in Fluid Construction Grammar (FCG). Readers are not required to be familiar with FCG for understanding the paper's arguments, but those who are interested are advised to check the introduction to FCG by Steels (to appear), and to check out the web demonstrations at http://www.fcg-net.org/ that show that the constructions proposed in this paper are fully implemented and work for both language formulation and comprehension.

In order to make the paper's proposal concrete, I will use the sentences of example (19) as a reference point. The example shows one "canonical" sentence and six deviating patterns that are traditionally analyzed as involving unbounded dependencies. I will show that all of these sentences can be analyzed using the same lexical entry for *read* and the same argument structure constructions, and that different word orders arise as a spontaneous side-effect of how grammatical constructions interact with each other.

(19)

Example	**Mainstream analysis**
The man read the book.	Canonical order.
The book the man read.	Topicalization
The book that the man bought and read.	Topicalization, "parasitic gap"
Who read the book?	Subject-wh-fronting
What has the man read?	Object-wh-fronting, inversion
What did the man read?	Object-wh-fronting, inversion, do-support
Who do you think has read the book?	Subject-wh-fronting, do-support, long-distance agreement

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3.1 Expressing event-participant structure

Most of the world's languages provide their speakers and listeners with grammatical conventions for expressing and understanding "who does what to whom". In a construction grammar approach, these relations are expressed through an interplay between lexical constructions and argument structure constructions (Goldberg 1995; Croft 1998; Perek 2015). These kinds of constructions divide the labor roughly as follows (van Trijp 2015):

- Lexical constructions:
  - Verbalize the *semantic frames* that the speaker has used for conceptualizing the state-of-affairs (Fillmore 1975). For example, a read-frame may involve the *frame elements* such as the *reader* (e.g. a person or a device), the *object-of-reading* (e.g. a book), and so on;
  - Stipulate how they *align* with grammatical constructions. For instance, English verbs take either accusative or ergative alignment.
- Argument Structure constructions express how the speaker has *profiled the event* by mapping a semantic frame onto a particular functional structure. They may use the combinatorial potential of lexical constructions for doing so, or coerce them into new functions as long as there are no conflicts.

As shown in formal detail by van Trijp (2011, 2015), this division of labor allows *multiple argument realization* for the same lexical entry. That is, the same verb may occur in different argument structure patterns without requiring any *lexical rules* to intervene (i.e. derivational rules that modify a verb's valence). Let us illustrate how this is possible. Example (20) shows the event-participant structure of the verbs *break, buy* and *read* (formalized with an elementary predicate calculus) and their alignment. Symbols that start with a question mark are variables.

(20)

Verb	**Event-participant structure**	**Alignment**
break	{ break(?ev), breaker(?ev, ?x), broken(?ev, ?y) }	Ergative
buy	{ buy(?ev), buyer(?ev, ?x), bought(?ev, ?y) }	Accusative
read	{ read(?ev), reader(?ev, ?x), read-thing(?ev, ?y) }	Accusative

Accusative and ergative alignment puts constraints on how the participant roles of a verb fit into the slots of *argument structure constructions*. Examples (21)–(24) illustrate some argument structure constructions and how they accept different kinds of verbs.

(21) *Active Intransitive construction:* maps the most Agent-like participant role of accusative verbs or the most Patient-like role of ergative verbs onto subject.

  a. *The window*$_{[broken]}$ *broke.*

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b. *I'm not selling,* $I_{[buyer]}$ *am buying!*
c. $I_{[reader]}$ *was reading.*

(22) *Active Transitive construction:* Maps the most Agent-like role onto Subject and the most Patient-like role onto Object.

a. $I_{[breaker]}$ *broke the window*$_{[brohen]}$.
b. $I_{[buyer]}$ *bought the book*$_{[bought]}$.
c. $I_{[reader]}$ *read the book*$_{[read\text{-}thing]}$.

(23) *Mediopassive construction:* Maps the most Patient-like role onto Subject.

a. *Glass*$_{[broken]}$ *breaks easily.*
b. *One euro*$_{[bought]}$ *buys at roughly 1.14 US dollars.*
c. *The book*$_{[read\text{-}thing]}$ *reads easily.*

(24) *Active Ditransitive construction:* Similar to the Active Transitive construction, but additionally either imposes a Beneficiary role onto the verb through coercion or it expresses the most Beneficiary/Recipient-like participant role of the verb as Indirect Object.

a. *He*$_{[breaker]}$ *broke them*$_{[beneficiary]}$ *some bread*$_{[broken]}$.
b. *He*$_{[buyer]}$ *bought her*$_{[beneficiary]}$ *flowers*$_{[bought]}$
c. $I_{[reader]}$ *read her*$_{[beneficiary]}$ *a bedtime story*$_{[read\ —\ thing]}$

3.2 Expressing functional and information structure

At first sight, argument structure constructions can be discarded as mere notational variations of derivational lexical rules because such rules can modify a verb's valency and account for multiple argument realization in this way. One major difference, however, is that argument structure constructions do not require their constituents to be in their immediate domain and can therefore be distantly instantiated. Instead, argument structure constructions interact with functional constructions and information structure constructions, which regulate the order in which constituents are presented to the listener.

3.2.1 *The subject as a vantage point*

Whereas grammatical relations such as Subject and Object are demoted to syntactic positions in tree-based analyses, they are assigned important conceptual roles in functional linguistics. In this paper, I will follow the proposal by Dik (1997) who defines the Subject as the *primary vantage point* from which an event is described. For example, in a sentence such as *the man bought the house,* the scene is described from the viewpoint of the buyer (the most Agent-like role), whereas in the passive

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sentence *the house was bought by the man,* the same scene is described from the perspective of the item that was bought (the most Patient-like role). The English grammar offers its speakers a reliable way to identify the subject of a sentence, which can be summarized in the following rule:

– The subject of a clause must be an NP that precedes the lexical verb that governs the clause. Moreover, Subject and Verb must agree with each other in Person and Number.

Figure 1 shows a computational formalization of this rule in the form of a construction in Fluid Construction Grammar. For readers who are interested in the formal details: the right-hand-side of the construction determines when it is appropriate to activate the construction. Here, the construction specifies that it requires one constituent to play the Subject role (*?subject)* and one that is the verb phrase *(?vp)* of the clause. The third box (root) contains information that can be observed in the input (i.e. the sentence that was observed in comprehension or the meanings that were conceptualized in formulation).

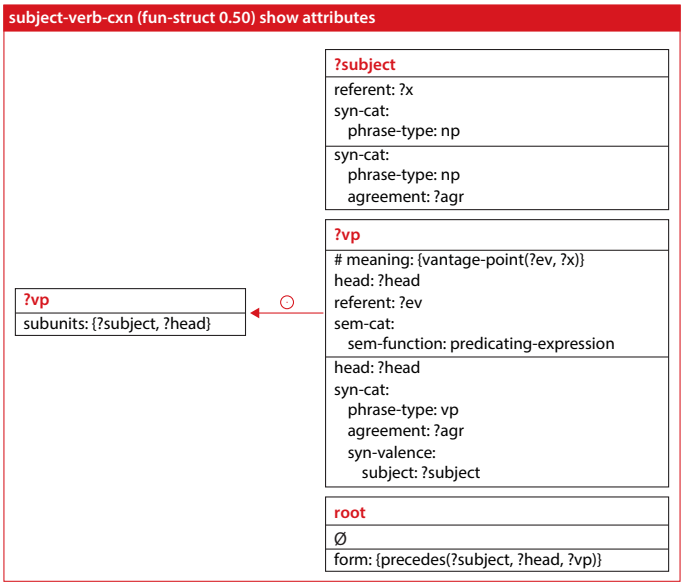

Figure 1. A computational representation of the Subject-Verb-Construction from the FCG web interface. The right-hand side of the construction shows the *conditional* part of the constructions: these are units that need to be supplied by other constructions before the Subject-Verb-Construction is activated. Each conditional unit is in turn divided into a *formulation lock* (above the line) and a *comprehension lock* (under the line), which specify the constraints that must be satisfied before the construction contributes additional information. The left-hand side contains the *contribution* part of the construction.

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In comprehension, all of the feature-value pairs that are shown below the full line in each box act as constraints that need to be satisfied before the construction is activated. The *root* specifies that there must be a precedence-relation between the *?subject* and the *?head* of the *?vp.* Question marks indicate symbols that are variables, so the construction must actively identify which constituents or units can be assigned to those variables. The other boxes provide more constraints that will help the construction to do this: the subject must be an NP and the verb phrase must be a VP. Moreover, both units must contain a feature called **agreement** whose value must be the same (indicated by repeating the same variable *?agr)* in both units. If these constraints are satisfied, the construction will add all the other feature-value pairs (including the left-hand side of the construction) to the analysis of the sentence.

In formulation, the construction will only be activated if the constraints are satisfied that are specified above the full lines in each box on the right-hand side. The most important box concerns the VP: as can be seen in the **meaning** feature, the construction expresses that the vantage-point of the event (*?ev)* must be *?x.* The variable *?x* is repeated as the value of the feature **referent** in the *?subject* unit. If these constraints are satisfied, the construction will impose a precedence relation between the subject and the lexical verb of the VP (bound to *?head)* and agreement between both constituents.

3.2.2 *English as a Focus-First language*

English is often categorized as an SVO language, but in this paper I propose that English is predominantly a Focus-First language. I define "Focus" in terms of *aboutness:* in the utterance *the man read the book,* the speaker makes an assertion about *the man,* whereas in the sentence *the book the man read* asserts something about *the book.* The placement of the Focus can be summarized as follows:

– The Focus of a clause is an NP that precedes all other constituents of that clause.

Figure 2 shows a computational representation of the Clause-Focus Construction, which captures this rule. Interestingly, the combination of the Subject-Verb Construction and the Clause-Focus Construction has certain side effects: when the Subject is chosen as the Focus of a clause, we get the canonical word order as in *the man bought a house.* If, however, the Object is conceptualized as the Focus, we get the marked word order *the house the man bought.*

Can these constructions also handle tricky examples, such as *The book that the man bought and read?* In mainstream linguistics, such sentences are analyzed as involving two gaps in the Object position after each verb: *The book that the man bought*$_{[Gap1]}$ *and read*$_{[Gap2]}$. Moreover, the gaps are called *parasitic* because they can only appear in each other's presence, as it is unacceptable to say **The man bought*

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the book and read$_{[Gap]}$. Mainstream linguistics must therefore call yet another device into existence for explaining this phenomenon.

In a construction grammar approach, there is no need to stipulate two gaps: the sentence simply adheres to the two aforementioned constructions: the Focus of both verbs *(the book)* takes initial position, and the Subject precedes the verbs. The fact that utterances such as **The man bought the book and read* or **The book that the man bought and read it* are not acceptable is easily explained as well: the verbs *bought* and *read* are coordinated with each other, which implies that they share the same information structure. The unacceptable utterance would require the speaker to shift information structure in the middle of the coordinated clause (and thus apply a different information structure construction), which makes no sense from the perspective of successful communication.

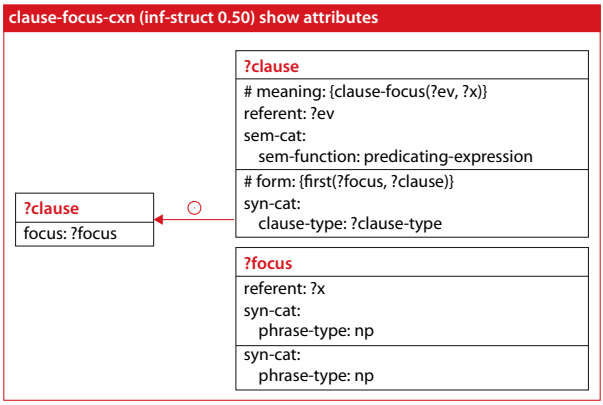

Figure 2. A computational representation of the Clause-Focus Construction from the FCG web interface. The construction identifies the first NP of a clause as its focus (in comprehension) or states that the Focus should be the first NP of that clause (in production). The label *first* in the clause's FORM feature does not imply immediate precedence and still allows the Focus of a clause to be distantly instantiated.

3.3 Illocutionary force

We now turn to *illocutionary force*. Besides expressing event-participant, functional and information structure, the speaker must also indicate the *speech act* of the utterance. Recent research has suggested that English uses *Subject-Auxiliary Inversion* to mark the difference between declarative and non-declarative clauses (Goldberg and Del Giudice 2005). The following rule can indeed be posited to mark the difference between declarative clauses and WH-interrogatives:

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– The placement of the finite verb form of the matrix clause marks its speech act. It must follow the subject in declarative matrix clauses, but follow the Focus in WH-interrogative matrix clauses.

Together with the previous two rules, this "simple" convention explains two problems in the analysis of WH-questions: why subject-WH-interrogatives do not involve subject-auxiliary inversion, and why English has do-support in the absence of an auxiliary for non-subject-WH-interrogatives. Let us first look at example (25).

(25) 

As can be seen, the subject *Who* precedes the lexical verb *read* [1] The subject is also the Focus of the clause, hence it precedes all other constituents of the clause [2], and it is followed by a finite verb form [3]. Now when we look at example (26), we see the same three constraints in action, but this time yielding a different order in the final sentence. The subject *he* precedes the lexical verb *read* [1], but the Focus of the clause is now assigned to the Object, which takes clause-preceding position [2]. Since the sentence is a WH-interrogative, the finite verb form must follow the Focus [3], which causes an Auxiliary-Subject order as a side effect (not as the result of a special rule).

(26) 

But what happens when there is no auxiliary and the Focus is not assigned to the subject? In that case, there would be a conflict between the convention that the Subject must precede the lexical verb [1] and that the finite verb form must follow the Focus [3] In this case, do-support solves the conflict, as shown in example (27).

(27) 

Even when moving to "real" unbounded dependencies, the same three constructions interact with each other. Example (28) shows that the Subject-Verb Construction places the Subject of the matrix clause *you* before its lexical verb *think.* The Clause-Focus construction ensures that *who* takes clause-preceding position, and the WH-interrogative construction requires a finite verb form to follow the Focus, hence we see do-support appearing [3]. Interestingly, *who* is also the Subject of two verbs in the subclause: *bought* and *read,* so the Subject-Verb construction is again activated to ensure a precedence relation between these constituents, and to ensure

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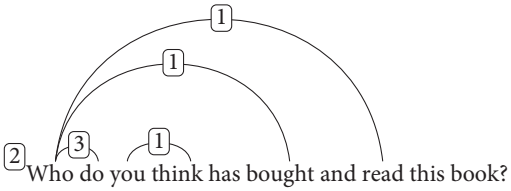
Subject-Verb agreement. Since the finite verb form is only exploited as a speech act marker in matrix clauses, the auxiliary *has* appears in its canonical position close to the verbs it modulates. In sum, the constructional analysis does not need to resort to derivational rules, parasitic gaps, feature percolation, long-distance agreement and filler-gap rules in order to account for this example.

(28)



One of the anonymous reviewers of this article asked an interesting question, namely how the above constructions would handle utterances such as the ones from examples (29) and (30).

(29) Who do you think did they pick? (Retrieved from www.feelies.org)

(30) Who do you think have they lined up to voice the character? (Retrieved from scienfiction.com)

Before answering the question, it is important to remember that we are operating in a cognitive-functional model where the grammar is not supposed to be a generative model that captures all and only the grammatical sentences of a language. A cognitive-functional model is usage-based, so variation and redundancy are expected to be abundant. In other words, there is no claim that the constructions I proposed so far can handle all utterances.

That said, how can we model the variation to explain these examples? One possible analysis is simply that there is constructional variation in the placement of auxiliaries. But there is also a possible analysis in which the conventions of the above constructions remain intact. There are good corpus-based arguments for assuming that these kinds of unbounded dependencies are highly formulaic, particularly the main clause *do you think* (Verhagen 2005; Dabrowska 2008; Dabrowska et al. 2009). It is therefore possible that language users may use *do you think* as an interjection and start treating the subclause as the actual main clause, in which case the above constructions apply as before.

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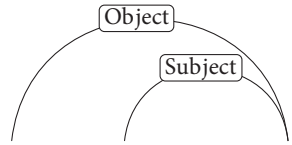
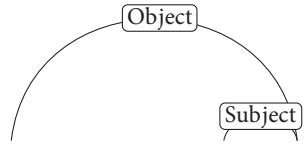
3.4 Processing preferences in argument linking

Mainstream linguistics considers the job of the grammar to delineate acceptable and non-acceptable structures in a given language, which takes the form of a *processing-independent competence model* (Sag and Wasow 2011). The competence model is said to *overgenerate* if it accepts ungrammatical sentences. Linguists who work in this approach might therefore worry that the constructions we have discussed so far lead to overgeneration. For example, if the Active-Transitive Construction does not impose a locality restriction on its constituents, what prevents this construction from generating wrong analyses for the subclause of the sentence *I read the book that you bought,* as shown in examples (31)–(32)?

(31)



(32)



The perhaps shocking answer is: nothing. Overgeneration is only a problem if grammar is implemented as a competence model, but that needn't be the case (van Trijp 2015). Grammar can also be conceived as an instrument for facilitating communication, as in cognitive-functional or usage-based linguistics. In this case, the task of the grammar is to help listeners to get to the meaning of a sentence as fast as possible, and to help speakers to make themselves understood. Instead of a binary yes-or-no approach, usage-based models thus require strategies for ranking different analyses. Indeed, we know from computational linguistics that the most robust language technologies that exist today are statistical models that "massively overgenerate analyses, but most of those analyses receive very low numerical scores, and so will be outranked by correct analyses" (Penn 2012, 165).

Computational linguists have been very successful in exploiting insights from probability theory to obtain useful statistics from text (Mannning and Schütze 1999). But useful heuristics have also been explored by cognitive-functional linguists and psychologists. In the remainder of this section, I will illustrate two powerful heuristics and how they cooperate with grammatical constructions.

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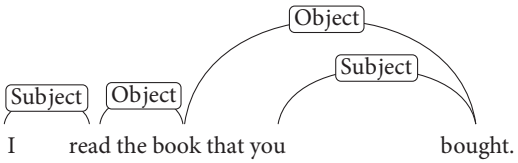
Prefer Local Linking. A widely accepted processing preference is to keep arguments that "belong together" as close as possible. This preference is known under different names in the literature, such as the Principle of Domain Integrity (Rijkhoff 1992) or the *Minimize Domains Principle* (Hawkins 2004), and has been made operational by Edward Gibson's *Dependency Locality Hypothesis* (Gibson 1998, 2000). Roughly speaking, the Dependency Locality Hypothesis states that it is more difficult for listeners to process unbounded dependencies because meanings must be kept active in memory for a longer time before they can be linked to other meanings. For instance, *the man bought the book* requires less processing effort than *the book the man bought* because argument linking is done locally, whereas in the latter example the referent of *the man* is introduced before the listener is capable of linking the meaning of *the book* to its head verb.

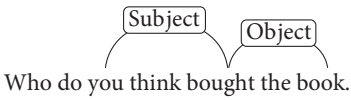
If local linking is preferred, the permissiveness of the Active-Transitive Construction is no longer an issue for our earlier example because the correct analysis will always outrank the alternatives, as shown in example (33).

(33)



Prefer Semantic Coherence. Obviously, preferring local linking is not sufficient for guiding linguistic processing. Example (34) shows that this preference would wrongly assume that *you* is the Subject of the subclause instead of *who.*

(34)



A second important principle is therefore to prefer analyses in which all meanings are linked to each other in a coherent way, which resembles pragmatic Relevance in the sense of Grice (1975). In the hypothesis where *you* is the Subject of the subclause, *who* would be left disconnected from the remainder of the utterance so the grammar does not help the listener in finding out how *who* relates to the rest of the clause. The correct analysis, on the other hand, would lead to a coherent structure where all meanings are connected.

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4. Conclusion

Mainstream linguistics uses syntactic trees as the basic representation device for the analysis of sentences. All other kinds of linguistic information, such as functional structure or information structure, have to be "read off" these trees, thereby demoting them to secondary notions in a grammar. Even though tree structures have interesting computational properties, they have important limitations for handling natural language. The most important one is that information can only be shared locally between a single parent and its immediate children. Information that needs to be shared beyond a local tree configuration therefore requires additional mechanisms. As a consequence, tree-based analyses need to resort to intricate solutions such as transformations or filler-gap rules (depending on the theory in which one operates) for handling issues in argument structure, word order and unbounded dependencies.

Cognitive-functional linguists, on the other hand, have proposed more intuitive analyses in which unbounded dependencies and word order variation are the spontaneous side effect of language usage. When communicative considerations are taken into account, it is clear that speakers do not only have to communicate argument structure relations to the listener, but they also have to manage how information is presented, and they must have clear communicative intentions (i.e. speech acts).

In this article, I have argued that it is perfectly feasible to implement the cognitive-functional analysis in a formally precise way through a construction grammar approach. Constructions offer a more expressive data structure than syntactic trees that are capable of capturing powerful generalizations. I have shown how a small number of constructions, implemented in Fluid Construction Grammar, may interact with each other to explain different word order patterns in English declarative and WH-interrogative clauses. Readers who wish to examine these constructions and how they are processed in more detail can download them at www.fcg-net.org.

The fact that constructions are able to capture such powerful abstractions does not mean that language users do not store and use lower-level patterns or prefabs in language processing. Indeed, one of the central tenets of usage-based construction grammar is that the construction inventory can be conceived as a complex network of constructions with various degrees of schematicity (Croft 2003; Bybee and Beckner 2010; Perek 2015). In order to study the interplay between low-level patterns and high-level schemas, it is of utmost importance to develop concrete processing models, and several proposals already exist within the framework of

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Fluid Construction Grammar for formalizing such networks (Wellens 2011; van Trijp and Steels 2012). Future research will have to continue to explore these relations between the representation, acquisition and processing of constructions.

Acknowledgements

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